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An Approach to Evaluating E-Business Information Systems Projects

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Abstract. *Capital investments in the e-business infrastructure add complexity to the IT payoff question because e-business interorganizational investments are deployed across multiple platforms, projects, vendors and partners. Traditional MIS research has been devoted to measuring the payoff from information technology (IT) investment without any specific focus on e-business. Flaws in the mature MIS performance measures seem to yield weak guidance for managers when evaluating IT success, thus diluting the potential for these measures to be adapted for use in the new e-business environment. A review of the conventional MIS payoff literature indicates that these measures may be incomplete, inaccurate, or inefficient for application to electronic commerce investments. This paper brings four new points to the e-business IT investment evaluation dialogue: (1) we first explore performance measurement validity flaws in our long established measures; (2) the paper discusses a two-by-two matrix delineating the gap between the quantitative versus qualitative performance measures of management information systems (MIS) initiatives; (3) sample e-business payoff techniques are discussed and reviewed in light of these historical imperfections, and (4) fourth, the paper proposes and describes an innovative framework derived from production theory economics for future research in evaluating e-business MIS implementations.*

Key Words. *system evaluation (UF), evaluation criteria (EI02), research frameworks (IB02), information technology adoption (EL05)*

1. Introduction

There are many studies in the management information systems (MIS) literature purporting to measure the success of information technology implementations (Benbasat, 1999). Yet, management information systems managers continue to struggle to evaluate potential projects and establish the bottom line impact of information technology (IT) investments to reaffirm linkages with both underlying MIS strategy and fundamental business strategies (Bharadwaj, 1999). At times, the overall impact of information technology may not be measured adequately (Brynjolfsson, 1993). The intricacies of e-business add yet another layer of complexity to the IT measurement problem.

E-business information technology investments are physically distributed between suppliers and vendors, making the investment payoff analysis potentially more difficult for evaluators to clarify (Klein and O'Keefe, 2001). The e-business technologies are in their infancy and many of these firm level investments represent innovative and cutting edge uses of information systems, adding to the risk and uncertainty of realizing positive downstream income effects. E-business IT investments have many potential uses, such as enhancing customer marketing and sales relationships or facilitating the acquisition of the input goods to production. E-business IT applications may have unique "black box" mechanisms that intervene in isolation or in combination to alter the final outcome variable of what constitutes firm success, e.g.: Does e-business technology yield increased customer awareness of firm products and thus increase firm online or offline sales; increase firm market competition via entry into global electronic markets and thereby decrease profit margins; allow increased specialization within the firm thus improving the yield and efficiency of production; or reduce either firm and/or consumer transaction costs?

Clearly, establishing the dependent variable and accurately measuring the success of e-business information systems technology implementations is an interesting problem for management information systems researchers. Indeed, resolution of the e-business dependent variable and measurement challenge is important for practitioners and MIS researchers alike. An effective framework for the evaluation of e-business projects should enable MIS managers to select between competing e-business solutions with confidence, allowing measurement of the degree of success in the implementation of information systems in terms of achievement of the e-business strategy, as well as generate improved capabilities to modify and predict future successful e-business MIS behaviors.

In this paper, four key points will be made. First, we will trace the evolution of the techniques by which MIS researchers measure IT payoff success, in order to make the point that the history of the MIS performance dependent variable has been tightly coupled to the information technology in use at the time. Second, a categorization of traditional dependent variable measures will be developed, using a matrix that modifies the DeLone and McLean (1992) typology to include a quantitative and qualitative criterion. Such a perspective exposes a gap in the center in terms of the nature of the analysis of the more conventional payoff measures that are employed. Third, current e-business IT payback measures will be evaluated in light of this historical perspective of the MIS performance evaluation literature, with interesting results. It appears that the new e-business IT payoff measures seem to share many of the same weaknesses as our earlier metrics. Finally, the last section of the paper will address the combined limitations of these technology-dependent measuring instruments as well as the restrictions of the discrete (e.g., either fully qualitative or quantitative) degree of analysis. Economic models are introduced as an additional potential tool to improve e-business valuation research by overcoming some of the weaknesses discussed in the traditional set of evaluation measures.

There are practical as well as technical reasons that e-business information technologies present additional payoff measurement challenges when compared to traditional information technologies. E-business IT investments are used to assist in the inter-firm acquisition of goods into the value chain (business to business, or B2B), and also to facilitate interfaces between customers, and vendors and sellers (business to customer, or B2C). An Internet-based infrastructure can be an investment that may yield competitive, strategic advantage for the e-business endeavor by melding the ownership of interorganizational exchanges across boundaries in horizontal or vertical markets, like Travelocity.com or Freemarkets.com. The transactions of B2B and B2C electronic commerce are facilitated by internets, intranets and extranets that function by linking suppliers and customers across the public networks of the web, using servers, routers and facilities belonging to a variety of owners and investors. Often, e-businesses use virtual, transparent networks built on top of third party owned infrastructures, applying customized overlays of privately funded encryption security like IPSec to construct virtual private networks tunneling through the public switched networks. Some B2B e-business activities are comprised of neutral electronic market exchange mechanisms, based upon partnerships with joint ownership of the exchange brokerage function, like the General Motors, Ford and Chrysler B2B procurement web site.

Some e-businesses choose to deliver electronic commerce transactions by controlling and managing all data processing functions internally, yet using leased facilities owned and managed by others for the transmission functions. Other e-businesses operate with a transactional pipeline that was subcontracted for on an end-to-end basis, including outsourced backoffice server software and shopping cart technology leased from vendors, becoming operational with little or no capital investment in the IT function. Some electronic commerce transactions occur as one-time events, while others are replicated frequently (e.g., a manufacturer may purchase an input good one time from one vendor via e-business links, while a customer may use e-business for a repetitive purchase for an online information good once a month). It seems, then, that the nature of e-business technology may make it harder to allocate and ascribe capital and operating costs to IT projects, further obscuring the accurate measurement of the performance effect of the IT investment.

It has always been a challenge to evaluate the return on investment for information systems technologies, even when these technologies were exclusively financed and operationalized within the domain of one firm. It seems that the very nature of today's e-business technologies may exacerbate problems inherent to applying IT payoff investment methodologies by blurring the lines of capital investment and return from IT expenditures in the B2B and B2C channel. Added to the difficulty of establishing a specific payoff from technology investments in e-business are the less quantifiable issues of trust, loyalty, demarcation of the boundaries of interorganizational networks and effect on expectations from the outcome of prior transactions. IT investments are freighted with measurement complexity (Lucas, 1999), and e-business IT investments may be more complex to evaluate than traditional IT investments due to the interorganizational nature of the technology.

2. Have Traditional Payoff Measures been Linked to the Technology in Use?

In the recent past, investors have had less than perfect objectivity about the potential returns from e-business firms, a phenomenon called the "Internet bubble" (Perkins and Perkins, 1999). Some have called this lack of overall investor objectivity "irrational exuberance" (Shiller, 2000). Perhaps e-business potential cannot be well evaluated in part because of the large role played by intangibles in its functionality, like knowledge, information or relationships (Blair and Wallman, 2001). Not unlike the .com boom investor biases, researchers have often been misguided by the prevailing mindset or paradigm of their peers (Kuhn, 1970). Effective managerial measures of e-business IT investment payoff success should be independent of the technology specific to the information system under evaluation, and isolated from miscalculations of enthusiasm attributed to .com market exuberance. Exploring measurement issues for the IT payoff in e-business will be enhanced with the following review of the literature regarding the weaknesses in existing, traditional MIS dependent variables.

2.1. IT payback has not been measured well in the past

It has been noted that there is a lack of coherence in MIS dependent variable research. For example, when modeled, information technology is sometimes conceptualized as the independent variable, and sometimes conceptualized as the dependent variable (Lucas, 1999). Early MIS research asked the question, "What is the dependent variable?" (Keen, 1980). Over twenty years later, the dependent variable for IT performance success remains unclear.

IS dependent variable research can be organized into three theoretical models: the technological imperative, the organizational imperative and the emergent process perspective (Markus and Robey, 1988). In the technological imperative model, IT acts as the independent, causal variable that impacts the organization in a measurable way. For Markus and Robey's organizational imperative perspective, information needs drive the IT selection, which then in turn impacts the organization. The organizational imperative suggests that IT is the dependent variable to the driver of organizational information needs. This model is somewhat reminiscent of the Cyert and March (1963) point of view, where a firm is organized around information needs and processes. The emergent process model, Markus and Robey's model of choice, describes a dynamic interplay between IT and organizational needs, the outcome of which ultimately has some downstream organizational influence.

Some of the uncertainty in IT effectiveness measurement comes from the contributory effect of information system intangibles, sometimes called the "garbage can model" (Lucas, 1999). This lack of adherence to any one theoretical model capturing the effect of technology has lead to dependent variable ambiguity, work scattered across disciplines, and variations in type of impact measured, all yielding an overall lack of consistency in the theory underlying MIS research (Markus and Robey, 1988). This discussion raises the question, does technology make the e-business, or does technology follow the e-business organizational and information needs? Firms like Dell, Cisco and Oracle both produce electronic commerce web sites for e-business sales and service to consumers, while simultaneously utilizing these same technologies for internal management activities and procurement over the internet. The linkages between technology and the business model are less distinct in e-business than in a more traditional business.

Beyond theoretical inconsistencies regarding how information technology impacts a firm, and presumably its bottom line payback, many have argued that IT impact has not been measured well. MIS measures may be subject to methodological weaknesses by researchers (Sethi and King, 1991; Brynjolfsson, 1993). Measurement problems cause much variability in the outcome results of IT organizational impact (Barua, Kriebel, and Mukhopadhyay, 1995). IT payoff research may need to accommodate interaction effects into measurement, such as incorporating the effect of strategy *and* IT to obtain a more accurate modeling of the IT/performance issue (Floyd and Woolridge, 1990). For the selection between capital investment alternatives, a good measure should consider the optional future earnings of a firm to assess an IT's potential impact (Dos Santos, 1990), yet few IT payoff measures consider this aspect of the IT investment. Additionally, applications of the user satisfaction construct as a measure of success or payoff from technology may be inappropriate because of expectancy value theory, e.g., even if the attitudes about the IT are accurate, these do not necessarily translate into subsequent actions by a user (Melone, 1990). Further, survey research, an important technique of IT performance evaluation, is conducted in such a way as to obtain inaccurate findings due to unknown biases in that questions are answered in a manner inconsistent with what the researcher may have intended (Hufnagel and Conca, 1994). Most measurement studies are U.S.-centric, and few encompass other industrialized economies, lending weakness to the ability to generalize measurements across country data (Tam, 1998). Overall, there is little consistency among the definitions of what constitutes IT, IT investment, firm performance, or the measurement methodologies of IT related organizational performance research (Weill and Olson, 1989; Weill, 1992). Not only is e-business technology investment interorganizational in nature, no single measure can easily be borrowed from the general MIS evaluation literature to address e-business technology investment decisions. Thus, applying traditional MIS measurement theory to the e-business payback problem may introduce imprecision in the modeling of the potential benefits.

In addition to the previously discussed weaknesses in underlying dependent variable theory and problems with methodology, the following section discusses the large variances in conventional measurement results. It may be that the measurement problems found in traditional MIS investment analysis are only magnified when applied in the less precisely bounded environment of e-business technology.

2.2. *Variability of traditional IT payoff measures and findings*

There have been inconsistencies regarding measuring the payoff from IT, chiefly in terms of definitions of the independent variable (Weill and Olson, 1989; Lucas, 1999). IT productivity measurement is by necessity an inexact science because products change from year to year, prices differ across markets, and accounting practices do not include knowledge assets (Stewart, 1997; Lester, 1998). We see a wide variation in assessment tools: IT budget as a percentage of revenues, IT investments per worker, IT expenditures as a percentage of total assets, or even owned versus leased computer ownership (Weill and Olson, 1989). Some studies include personnel and consulting services in the independent variable of IT, other studies only look at the information system equipment technology in isolation as the independent variable. According to Strassman, "There is no relationship between expenses for computers and business profitability," (Strassman, 1990, p. xvii), indicating that money spent and performance cannot be linked. Yet, Strassman generates IT expenditure data using a proprietary algorithm that calculates IT as a function of firm revenue (Strassman, 1998), causing validity questions for his IT payback conclusions.

Some of these concerns seem to relate to inconsistencies in the level of abstraction of the dependent variable. DeLone and McLean (1992) identify and characterize 180 different empirical studies on various measures of IT impacts on firm performance, most citations between 1981 and 1987. Higher levels of abstraction in theory may be paired with numerous related concrete measures when operationalized (Reynolds, 1971), and the MIS literature seems to bear this out. The dependent variables reported in the MIS literature range in scope from the tangible measures of response time, frequency of use, decision quality, dollar value of information generated, user productivity, and user effectiveness, to the more theoretical levels of abstraction such as IT impact on effectiveness of decisionmaking or downstream changes in industry structure. The more abstract the construct, perhaps the less quantitative it is when operationalized in a study. DeLone and McLean (1992) organize the proliferation of information technology dependent variables into six categories: System Quality, Information Quality, Use, User Satisfaction, Individual Impact and Organizational Impact.

Studies of MIS success are also varied in terms of the mix of qualitative and quantitative findings. Qualitative writings describe the positive influence of information systems on the strategic positioning of a firm in terms of corporate "competitive advantage" (e.g., Ives and Learmonth, 1984; Cash and Konsynski, 1985; Copeland and McKenney, 1988). Quantitative studies find for positive returns from IT use the macroeconomic variable level of "consumer value" (Hitt and Brynjolfsson, 1994). Some work indicates that higher amounts of IT spending correlate with improvements in organizational success in the insurance industry (Harris and Katz, 1991). Others report that firms where strategy and IT are aligned tend to have significantly higher return on assets attributable to the IT investment (Floyd and Woolridge, 1990). No productivity enhancement is reported in the services sector from applications of IT (Bender, 1988; Lester, 1998), sometimes spending decisions are based on "blind faith" on the part of MIS managers (Weill and Olson, 1989). Innovative uses of IT show a positive impact on the value of the firm, while non-innovative uses of IT are insignificant in affecting firm value (Dos Santos, Peffers, and Mauer, 1993). Transactions processing types of IT applications have a affirmative impact on performance, but strategic IT applications are neutral in the long run, and negative in the short run (Weill, 1992). Thus, various types of IT investments (innovative or transactional) may have different impacts (ROA, strategic or productivity enhancing) in different industries (insurance, service or non-service), and it is unclear how to best evaluate these differences when measures are not standardized in an accounting sense.

Issues with theory, measurement, operationalizing the dependent and independent variables and multiple variations of findings plague the MIS valuation research stream. This literature review implies that much work remains in the adoption and assessment of firm information systems projects in order to establish a framework for the evaluation of e-business IT investment payoff benefits.

2.3. Historic linkages: Are payback measures dependent on the technology?

It can be argued that the MIS dependent variable of choice is matched to the technologies in use at the time of a measure's emergence in the literature, yielding a potential lack of objectivity to the dependent variable construct (refer to Table 1). MIS can be divided into three arbitrary time segments of the Early MIS Period, Personal Computer Period, and the E-commerce, Client/Server and Enterprise Period (based loosely upon Nolan and Stoddard, 1985). If technology developments and MIS dependent variable research are loaded to this time axis, an interesting and subtle linkage between measurement and the information technology in use surfaces. The vertical axis represents various

Table 1. *History of MIS success valuation*

Periods of dominanting technology	1960's–1970's Early MIS period	1980's Personal computer period	1990's to today Electronic commerce, client/server and enterprise resource planning (ERP) period
MIS literature prevalent during period	Information processing view of corporate organization, Galbraith (1974), Cyert and March (1963): Information technology can automate repetitive processes. Cognitive Styles, Bariff, and Lusk (1977). Individuals learn and adapt to IT in different ways.	MIS for competitive advantage, Cash and Konsynski (1985), Porter and Millar (1985): Info. gives competitive advantage over the competition. Centralization vs. Decentralization debate, Managing PC's, Henderson and Treacy (1986), Rockart and Flannery (1983).	Interorganizational structures, enterprise wide orientation, IT can be used across organizations to improve business processes, team and group work: Learning organization, Senge (1990), Business process reengineering, Davenport (1992), Hammer and Champy (1992).
Typical IT evaluation dependent variable	Poor cost control issues: Brooks (1975), Large scale implementation issues: Argyris (1970), overall questionable IS effectiveness: Ackoff (1967), Dearden (1972)	User satisfaction: Bailey and Pearson (1983), Ives, Olson, and Baroudi (1983) End user computing: Doll and Torkzadeh (1988)	Macroeconomic level measures: Brynjolfsson (1993), Hitt and Brynjolfsson (1994), Enterprise level measures: Weill (1992), Harris and Katz (1991), Dos Santos (1991), Strassman (1990), context important in measure (Lucas, 1999), measure intangible effects of IT (Stewart, 1997; Blair, 2001).
Characterization of IT	Mainframes, large centralized databases, centralized DP hierarchy of control, backlog of projects, cost overruns, major transactions processing installations, custom programming	PC's introduced and spread at exponential rate, cracks emerge in centralized dataprocessing, dataprocessing has difficulty monitoring applications and hardware at end user level, renegade PC applications uncoordinated with mainframe activities	Client/server, distributed databases, Lotus Notes for workgroups, internet, world wide web, object oriented programming, wireless, cellular, networking cheap and available, intranets and extranets.

abstraction levels of MIS thinking, organized from the specific types of IT up to a more comprehensive MIS framework level of abstraction. Observing the dependent variables within each period suggests that technological advances in the field may drive the choice of measurement in the MIS valuation literature.

Reviewing the table, in the sixties and early seventies, MIS can be characterized as just beginning its general business rollout and impact. Systems were unsophisticated in terms of ease of use. Data processing at that time meant automating repetitive, programmable actions with transactions processing types of systems, and a typical installation required an expensive, customized programming effort. Many businesses were undergoing their first explorations with information technology. Backlogs for systems and applications development were common, often measured in years, and MIS was not highly regarded for its management (Brooks, 1995). Projects overran budgeted costs on an almost normal basis. This was a time of raised floor computer rooms, keypunch machines, card readers, and awkward, hardwired dumb terminal interfaces to user data via the mainframe. Timesharing was popular due to the high expense of owning and running a mainframe. Regular business employees did not interact with computers except through information systems specialists. During this period, even calculators were perceived as expensive technology.

Little IT measurement research was empirical in nature before 1979, and the *Management Information Systems Quarterly*, and the *Proceedings of the International Conference on Information Systems* were not yet published for the first time (Dickson and DeSanctis, 1991). The literature on the valuation of the impact of IT centered on the management and control of computer costs in the face of cost overruns (Dickson and DeSanctis, 1991). It appears that the Early MIS Period was one of exploration on the practitioner side of implementations as well as on the MIS researcher side measuring the value of implementations. Companies were figuring out how, when and why to use information technology. Compared to today, information technologies were arcane, complex and counter-intuitive, and not always a good return on investment.

At the same time, MIS researchers were evaluating the individual differences question in the cognitive styles literature. The cognitive styles research, although seemingly quite dated now, represented a very early step in the research stream that looks at how to improve the man/machine interface and IT performance. Cognitive style research was driven by the extant technology because it centered on how to design a better implementation, given that people were different in the way in which they adapted to new technology (Bariff and Lusk, 1977). Cognitive styles research implicitly assumed that the technology was inflexible in terms of the variety of delivery options. The cognitive styles literature is an example of an MIS research program framed by the limitations of technology of the time period.

The decade of the eighties can be called the Personal Computer Period. The first PC's were commercially available in the early eighties. PC's proliferated exponentially during this period. Centralized data processing (DP) began to come under fire, and the glass enclosed computer rooms began to lose the aura of mystique. Data processing department backlogs were circumvented by renegade PC users, many of whom expensed machines to avoid budgetary constraints on computer capital spending. The computing centralization debate began. Knowledgeable end users developed in pockets around corporations, and applications experts at the departmental level began to emerge, with or without DP's blessing.

Against this background, the user satisfaction instrument (Bailey and Pearson, 1983) and end user computing instrument (Doll and Torkzadeh, 1988) were popular in the MIS literature as surrogate measures of IT payback success. Bailey and Pearson made the observation that what makes users happy varies by the individual, and reflected this view with a questionnaire that allowed users to rank order the importance of various factors. The Bailey Pearson (1983) instrument reflects the technology of the times with a decidedly mainframe orientation. For example, Bailey Pearson asked users questions about their relative comfort with their "feeling of control" or "feeling of participation." Their user satisfaction instrument inherently assumes that satisfied users are a surrogate for information system success.

Only a few months later, Ives, Olson, and Baroudi (1983) modified the basic instrument, and suggested improvements to it. Five years later, still in the Personal Computer Period, Doll and Torkzadeh (1988) create an again technologically dependent instrument reflecting the meteoric dissemination of PC's into the workplace. Now the questions included, "Is the system user friendly?" and "Is the system easy to use?" (Doll and Torkzadeh, 1988). They wrote, "Measures of user information satisfaction developed for a traditional data processing environment may no longer be appropriate for an end-user environment where users directly interact with application software (Doll and Torkzadeh, 1988:260)." As personal computers gained in popularity, the IT evaluation measures shifted from the user satisfaction instrument to the end user computing instrument. Again, evaluation of the IT payback was a function constrained by the technology of that period.

As MIS gained in respect, and began to gain momentum, references to strategic information systems and competitive advantage began to emerge in the literature as measures of the import at the corporate level of investments in IT. Cash and Konsynski (1985), Ives and Learmonth (1984), and Porter and Millar (1985) are examples of the shift in the evaluation literature to reflect IT's contributions to competitive advantage to the firm as the dependent variable.

The nineties and on into today saw the introduction of the E-commerce, Client/Server and the Enterprise Period, which was a technical unification of the polarity of centralized data processing and decentralized data processing via the improvements in client/server, distributed databases and networking technology. Consultants, outsourcing and the specialization of knowledge workers emerge in this time period. IT began to be viewed in some circles as a business necessity instead of a weapon for strategic advantage. The learning organization (Senge, 1990) and business process reengineering (Davenport and Short, 1990; Hammer, 1990; Hammer and Champy, 1993; Grover, Teng, and Fiedler, 1993) became the vanguard of what made MIS important to practitioners in the face of the highly competitive, global business environment of the Enterprise Period. Unlike the Personal Computer Period, the technologies of client/server, ERP systems from Baan and SAP, and distributed processing as well as the reengineering style deployments of IT are enterprise wide applications. The information technologies of this era are far more capable of what Dearden (1972) and Ackoff (1967) found to be the limitations of information systems of the sixties. Still, few e-business payoff measures are evident in the literature until the very late nineties.

Consistent with the theme that technology drives the IT payoff metrics, measures of success begin to reflect an enterprise wide theme in the nineties as well. Brynjolfsson and Hitt (1993), for example, use macroeconomic level data from 367 firms to determine that expenditures on IT have led to increases in business performance (defined as consumer value) for firms. Gone was the user satisfaction instrument, while researchers find that innovative IT expenditures have a firm level return as measured by changes in market stock price value (Dos Santos, Peffers, and Mauer, 1993). Weill (1992) defines the dependent variable of firm performance using quantitative data such as return on assets and the number of non-production employees per sales unit. IT performance can be measured with a dependent variable constructed from enterprise level items such as market share, return on assets, inventory turnover, and capacity utilization (Barua, Kriebel, and Mukhopadhyay, 1995). Later in the decade, even larger concerns such as knowledge management and intellectual capital contributions become the focus of IT payback research (e.g., Stewart, 1997; Lucas, 1999). For the first time, some of the "productivity paradox" literature was successful at achieving solid, empirical results about IT expenditures.

Although anecdotal evidence suggests that the valuation techniques seem to be improving over time, the dependent variable of the effects of IT will continue to remain unclear and indistinct until the linkage to that very technology that is being measured is broken. Validity is an evaluation as to "the extent to which any measuring instrument measures what it is intended to measure" (Carmines and Zeller, 1979:17), and construct validity is concerned with how well our measures capture the underlying attribute (Cronbach and Meehl, 1959). If the independent variable construct is measured by capturing levels of that IT which is implemented, such as amount of expenditures, type of system in terms of level of innovation, or the nature of infrastructure such as extent of reach of E-commerce network, and the dependent variable is a very similar construct such as user satisfaction with the exact system installed or page views of a web site, and not some other independently derived alternative, then it is methodologically difficult to isolate the measurement of the independent variable from the measurement of the dependent variable. It is methodologically acceptable if an independent variable is positively *correlated* with a dependent variable, indeed that is what the MIS research is seeking to find between IT and its impact. But, if that correlation is due to a *lack of uniqueness* associated with the operationalization of the measures, it makes for flawed performance results in terms of the validity of the construct. Instead, techniques that rely on a blending of qualitative, quantitative and economic modeling may give a way to triangulate the

IT evaluation problem, thus increasing the construct validity of the measures.

This discussion suggests the notion that any innovative framework for evaluating e-business payback must then attempt to dissociate the dependent variable measure of performance or success from the measure of the technology under review. The next section will address the sharp dichotomy between the strongly qualitative or strongly quantitative measures, while the fourth section reviews samples of existing e-business measures against this backdrop. The last section introduces some possible improvements based in production theory economics to the e-business investment decision modeling process in light of these criticisms.

2.4. Gaps between the quantitative and qualitative measures of MIS success

A matrix which arranges payback measures by influence level, and by the relative strategic versus efficiency characteristics of the measure illuminates more IT payback shortcomings in the MIS literature, and suggests additional changes to include in an improved framework for research in e-business IT paybacks.

DeLone and McLean (1992) orient their review of 180 historical dependent variable MIS studies along a continuum that ranges from the technical or system level of analysis out to the organizational level of analysis. According to DeLone and McLean, the typology is derived from the narrower Shannon and Weaver (1949) Information Theory view, and upon Mason's (1978) categorization of the dependent variable. Unit level of analysis is the defining characteristic of the typology. DeLone and McLean stop short of creating a category for the societal or industry level measures of Brynjolfsson and Hitt (1993), Weill (1992) or Dos Santos, Peffers, and Mauer (1993). Indeed, Kemerer (1998) suggests that future research may take the IT payoff discussion to a more macroeconomic level in time. Interesting observations arise when research is sorted and distributed according to a qualitative versus quantitative matrix.

This categorization of dependent variable measures seems to expose a gap in the center in terms of the degree of analysis of the payback measures that have been employed in the past in MIS research. Although the qualitative measures seem more holistic, and ultimately may get at the root issue of whether a system is of benefit in an intuitive, all-inclusive way, qualitative benchmarks are lacking in the rigor that senior management needs in order to evaluate competing uses of capital (Dos Santos, 1991). On the other hand, the strictly quantitative measures of Table 2 may give MIS executives the ammunition required to obtain top management funding for a technology implementation, but are often so rigorous that only the most obvious of IT implementations will prevail.

The elusiveness of quantifying the IT payback has been called the "Productivity Paradox" (Brynjolfsson, 1993; Lucas, 1999). This review of the MIS payoff research stream implies that a good e-business IT investment measurement process should not be so qualitative that it encourages inappropriate investments, nor so quantitative that it causes potentially good projects to be rejected.

Table 2. *Dependent variable qualitative versus quantitative gap by organizational level*

	Qualitative (Perceptual, intentions, and opinion)	Quantitative (hard, typically financial valuations)
Organizational, firm level, industry level	Strategic, competitive advantage, barriers to entry, etc.: Cash and Konsynski (1985), Ives and Learmonth (1984), Porter and Millar (1985); Innovativeness: Keen (1988); Indirect benefits: Dos Santos (1991); Intangibles like flexible culture: Powell (1997)	Return on assets, sales growth, labor productivity: Weill (1992); Market value changes in response to IT: Dos Santos, Peffers, and Maner (1993); Impact of MIS intangibles on firm market value: Grove, Frank, and Hanbery (1990); Firm performance in terms of IT impact on cost efficiency, income of firm: Harris and Katz (1991)
User, process, operational or unit level	User satisfaction: Bailey and Pearson (1983), Ives, Olson, and Baroudi (1983); End user computing: Doll and Torkzadeh (1988)	Technical benefits such as information simplicity, legibility: Westland (1990); Direct benefits: Dos Santos, Peffers, and Maner (1993); Operational cost savings benefits, such as return on management: Strassman (1990).

2.5. E-business payback variables share technological dependency and qualitative vs. quantitative extremes

Preliminary, subjective evidence of the newly emerging e-business payback variables suggests that these new measures share many of the same validity and reliability issues evidenced in earlier IT valuation approaches. For example, some e-business dependent variables count unique page views as evidence of performance in generating traffic (Alpar, Porembski, and Pickerodt, 2001). Yet, it can be argued that page views are a theoretically weak proxy dependent variable purporting to measure the construct of IT payback performance. Evaluating page views as a surrogate for firm IT investment success from an IT web site deployment has little methodological distinction between the independent variable of IT and the dependent variable measurement of IT success in order to create construct validity in the two measures. Another study uses the web itself to evaluate e-commerce success, with somewhat equivocal results (Vehovar, Manfreda, and Batagelj, 2001), and this measurement shows a similar dependent variable technological dependency. Other measures of e-business success look at "click through" counts, cost per customer "eyeball", and add up ad revenues (Lee, 1999). With the exception of ad revenues, each of these surrogate measures for e-business IT performance are highly related to, and not very distinct from, the technology choice, just as were the user satisfaction constructs found earlier in the MIS evaluation stream literature. It seems as if e-business evaluation is following the pattern of weaknesses established in the traditional IT payback measures. There is very little evidence of any research that attempts to track the payback while differentiating ownership of costs and benefits in interorganizationally connected information systems.

E-business price dispersion measures show that some e-business firms are able to retain customers when charging higher fees than competitors, despite the near perfect information availability of the internet, while other e-businesses cannot withstand price differentials (Brynjolfsson and Smith, 2000). This finding suggests that e-business success may lie more with investing in those technologies that help to establish consumer feelings of trust and security than with those technologies that enhance transactional efficiency, such as an Amazon.com approach. Consumers may save transactions costs by purchasing in the online, e-business environment, but those savings ignore the customer's higher information processing costs accrued in the e-business endeavor (Hong, 2000). Rangone and Balocco describe a comprehensive model of performance measurement in e-business, but it is not related to IT investment returns, but rather is focused on controllable marketing variables (Rangone and Balocco, 2000). It seems that costs and returns on IT investments in electronic business are often not what they appear on the surface for both consumers and producers, and difficult-to-measure constructs such as transaction costs, interpersonal trust and feelings of transactional security are also part of the e-business cost and benefit environment. Eyeballs, click throughs, page views, ad revenues, and marketing cost savings do not offer the total solution to the e-business information systems evaluation problem. What few techniques that do exist for measuring e-business IT success seem to be weighted more in the marketing realm as compared to the production side, aimed at evaluating the effect of e-business on marketing, sales, reaching customers, or in making an online sale. Indeed, perhaps the failure of many .coms was more a problem rising from the demand side than on the production side of the information systems performance equation.

3. Towards an Economic Model Perspective of E-Business Payoff Measures

Applications of economic theory may add depth to the e-business payoff valuation research by overcoming some of the described weaknesses in the existing set of measures. Deploying a substructure of economic modeling in addition to the traditional measures may address the combined limitations of technology-dependent measuring instruments as well as the restrictions of a discrete (e.g., either fully qualitative or quantitative) degree of analysis by adding construct validity to the process of evaluation. Some examples of research that employs economic modeling fundamentals in IT analysis include a study of the effects of price changes on the demand for computing power (Gurbaxani and Mendelson, 1990), a look at the benefits of MIS auditing in terms of marginal costs (Westland, 1990), network externalities to assist in the pricing of internal MIS services (Westland, 1992), and the application of utility curves to the problem of optimizing database design (Beggs, 1989). The creative application of economic models may generate innovative and conceptually abstract ways of thinking to improve e-business IT payback measurement. The most interesting potential for contributing to new ways of conducting e-business technology measurement may be in terms of applications of simple models from production economics.

In a post-.com business environment, of particular interest is the need to address the production aspects of e-business information systems performance, specifically regarding the effect of technologies on efficiencies of production, generating increased output, or producing better goods with the same amount of inputs to production. Many e-businesses manufacture information goods products, such as software, consulting, music, and service, which in some instances can approach nearly zero marginal production costs, and as such may be subject to unusual economic effects such as increasing or constant returns. Some researchers argue that the electronic commerce based firms operate at a faster product cycle time tied to the speed of technological change (Shapiro and Varian, 1999). These firms may experience a more rapid rate of change of both information product development as well as information technology applications turnover (Mendelson and Kraemer, 1998). Information goods firms may not only produce information, but utilize the very products which they produce to accelerate into the next new product cycle (Cusumano and Yoffee, 1998). E-business new product development is nearly parallel to current product development (Shapiro and Varian, 1999). The previously discussed qualitative and quantitative measures of IT deployment and IT success are not sufficient in isolation to achieve an effective answer to the very short window within which IT investment decisions must be made in e-business, nor do the traditional measures explore well the issue of increasing returns to goods with zero marginal costs of production. This paper suggests that the traditional MIS evaluation may be improved upon by blending together the qualitative and quantitative MIS measures together with applications of basic production economics tools.

3.1. Economic concepts readily applicable to the e-business IT payback problem

Several examples of basic economic analytical tools will serve to demonstrate that economic models may potentially be useful if appropriated by MIS researchers for thinking through e-business scenarios. The following section describes some examples of relevant economic models as well as descriptions of how these models might be empirically tested in a real world application.

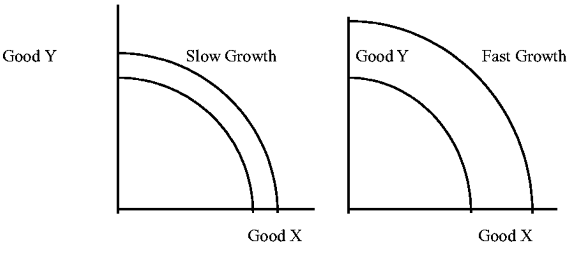

Fig. 1. Technology investment and production levels.

Production possibilities frontier. The production possibilities frontier (PPF) models scarcity and choice, and shows the maximum possible combinations of output quantities x and y that can be produced. Technology, or IT, is assumed to push out the curve, increasing the total amount of combinations of goods that can be produced from the same set of resources (see Fig. 1). More technology is inherently assumed to yield more goods produced, e.g., more e-business goods delivered. E-businesses must answer the question of if technology deployment will yield faster growth in terms of improved efficiencies at production, or only result in increases in pages viewed and "eyeballs?"

To test this conceptual model in a real world, electronic commerce in the business is enabling faster growth inproduction of output than was previously known with prior technologies. Assuming that pre-e-business production levels were 100 shipments of shrink wrapped software per week, 50 units of Good Y and 50 units of Good X, one would then expect to see the production of software shipped to be 75 units of Good Y and 75 units of Good X. In this example, production was increased through applications of e-business technologies such that there were internet downloads for Goods X and Y, enabling the same firm resources to achieve increased production throughput because of the improved efficiency of delivery attributed to the e-business infrastructure. Thus, management would look at the volume of production of goods for the period prior to the firm's e-business deployment, and the volume of production of goods post e-business deployment, and attempt to discern if the investment in e-business IT fostered the potential to produce more goods with the same labor and capital, all else equal.

Information technology capital expenditures vs. alternative types of capital expenditures. An e-business executive must rank relative capital expenditures and select those with the highest rates of return in order to maximize firm performance, knowing full well that the rate of return ininformation systems projects may not be as readily quantifiable as other, more traditional investments. Isoquant curves model equals levels of output between two variable input levels (see Fig. 2). Anywhere along a specific isoquant curve, an actor is equally indifferent to the combination of information technology units or alternative capital project units because production levels will be exactly the same all along the curve. To improve production, however, a curve must shift outward from the first isoquant curve. If the e-business venture selects more and more IT input units, they select fewer and fewer alternative capital project units. In this example, if the management is not willing to substitute equally between IT units or alternative capital units, the isoquant curve is convex, indicating a tradeoff in productivity in the mix of the selected combination for that isoquant level.

The best combination of e-business IT and alternative capital units is that point where the highest level of production intersects the constrained budget curve, or isocost curve. The isocost curve represents the exchange ratio between the two selections at a given level of resources. The tangent represents the maximized satisfaction combination of projects (furthest out indifference curve) that the e-business can reach, given the constrained isocost line. If the e-business obtains more capital financing, the isocost curve will shift rightwards, reflecting the new isoquant production curves which can be reached.

As e-business IT becomes cheaper relative to the alternative capital projects, the isocost curve shifts to reflect this change, and more e-business IT units are selected at the tangent optimal mix of input goods. In

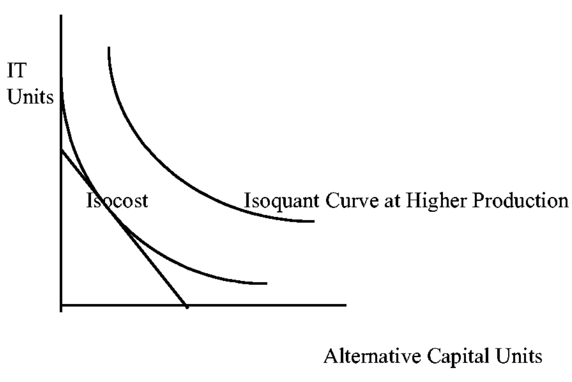

Fig. 2. *Isoquant curves at two production levels.*

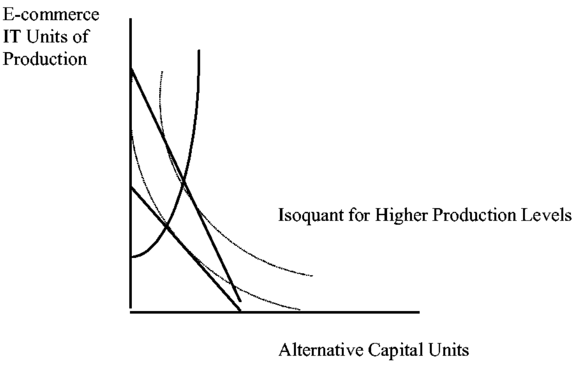

Fig. 3. *E-commerce IT selection bias over alternative captial over time.*

this example, e-business information technology becomes cheaper relative to alternative capital project choices, indicated by the bias towards selecting information technologies over other capital investments to achieve higher production volumes (Fig. 3). Once IT is perceived as the more efficient and productive input good, this bias may be selected in the e-business in every case, when this choice is not always the best capital investment alternative.

Over time, as the relative cost of IT improves as compared to alternative capital costs, higher and higher isoquant curves are reached, representing higher production at the same level of input resources expended attributable to the improvements in IT units of production purchasable for the same price. The curve connecting the tangent points reflects the trend over time for the factors of production to favor IT units over other capital units due to enhanced productivity from technology relative to other kinds of capital. Indeed, there may be a false lure to overspend on IT investments relative to alternative capital projects as the productivity enhancements pull the tangent points in a leftward pattern over time. The CEO in our example may overshoot the mark and use more IT units than alternative capital units in the production mix because of the expectation that the productivity of IT relative to other factors may continue to improve, when that may or may not be the case over the life of the production sequence.

To empirically investigate this model in a business application, a manager must gather data and reflect back on the capital budgeting committee portfolio of investment decisions over a period of time. If two capital budgeting decisions were of equal return in terms of internal rate or return, payback or net present value, and one decision was a technological capital improvement while another was an alternative capital improvement such as building a factory or adding another company, and the IT decision was the accepted project, then an IT bias pattern can be discerned in the capital budgeting committee decisions over time. Evidence of a bias in selecting IT might indicate that there is a falsely perceived lure to choose information technology over alternative capital investments. For example, a manager might determine that IT projects were twice or three times as likely to be funded than other comparably rated and assessed capital projects, perhaps in terms of investment dollars and internal rates of return or months to payback. At a certain point, this bias toward IT investment becomes a weakness in the diversity of the capital portfolio, and adds risk to the firm. Further, a tendency toward selecting IT investment over all other capital expenditures may weaken the overall potential effectiveness of the IT investment in achieving performance results. This would be able to be diagnosed by MIS managers by applying an average total cost curve approach to the e-business evaluation problem.

Diminishing returns. It is interesting to speculate if an over-selection of IT over other capital investments in the e-business environment may push past the optimal IT expenditure level to a position where the average total production costs are rising. Fig. 4 is a representation of the ideas of economies and diseconomies of scale.

Indeed, diseconomies of scale may reflect why some of our general MIS evaluation studies do not show a positive return for IT on firm performance. Some of these previously reviewed studies may be picking up specific IT investments on one side of the equilibrium or the other. This model seems to indicate that there may be some optimal level of e-business IT deployment for a firm.

Again, to test this model in an e-business environment would require an examination of the capital asset budget committee decisions over a time period of five years, for example, and then a computation of the benefits from each project in terms of production efficiency. The benefits could be estimated in an informal way using a Delphi technique, asking the best line workers to anonymously comment on the perceived efficiency contributions of each subproject that was added to the production system. In this way, some understanding might be reached as to which projects seemed to have a big effect on improving production efficiency, and which did not. For example, suppose one e-business installed an elegantly designed shopping cart, a searchable database, new servers to handle the increased sales volume and an automatic email response system for customer service, and each of these were valued by the orders and shipping department personnel as highly contributory to firm e-business success. If the firm then decided to invest in a highly sophisticated neural network based database for making customer purchase recommendations, yet no appreciable change in sales volumes resulted, then this project might receive low marks in terms of perceived efficiency effects. If so, then management should be cautious that the efficiency from investments in IT might have peaked at the company, and that no further efficiencies of production could be

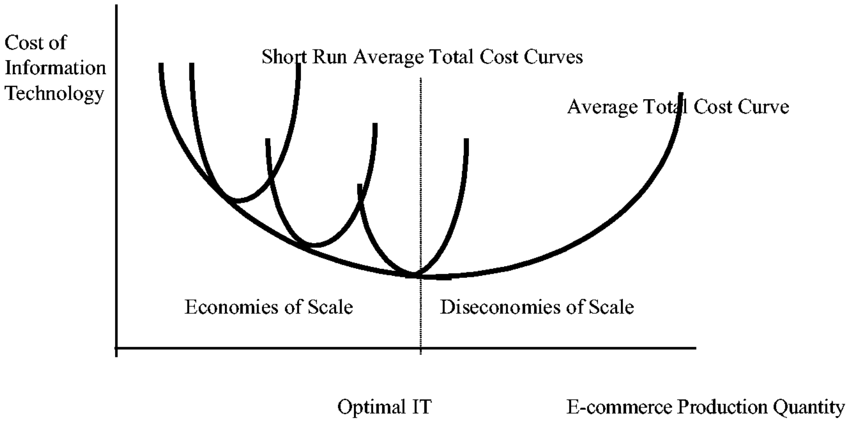

Fig. 4. *Optimal investment in technology.*

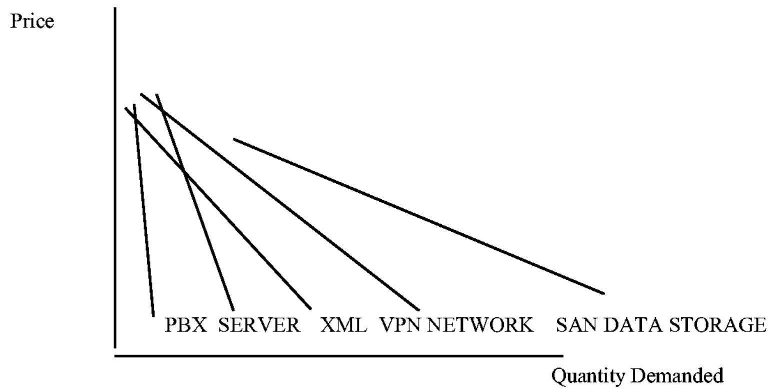

Fig. 5. *Hypothesized elasticities of demand for various IT investments.*

generated from e-business investment at current production levels.

In this example, if subsequent IT investments seem to be having less and less impact on productivity, perhaps capital investments in land (a new office or warehouse) or labor (additional robots or a new assembly line conveyor belt) might be a better choice for investment, even though the estimated internal rates of return or paybacks appear comparable for each type of investment. Thus, if the accumulated sum of projects are perceived as adding less and less of an impact in production efficiency, then the firm may have reached the point of diminishing returns from IT expenditures, and the company should be much more selective in choosing between alternative, yet seemingly equal, capital investments.

Elasticities of demand. Different e-business IT solutions may have different elasticities of demand. Just as salt is a product that is demanded at just about any price, so too may some E-commerce investments relative to other e-business IT's. Capturing various elasticities of demand for different IT products over time might yield insight as to which specific e-business IT is perceived to be more important than another. This may vary by industry, for example. A predicted series of elasticities might look something like Fig. 5.

With an inelastic demand, as in the price changes for servers, very little change occurs in the quantity demanded. Every firm must have dial tone, for instance, so one would expect to see that the demand for PBX equipment as being somewhat invariant at all price points. Yet, the demand for XML based electronic commerce, a new SAN (storage area network) data storage device or ATM network may appear to be more elastic, meaning that small price changes lead to big swings in demand.

Understanding the of elasticity of demand in a real world application would require the accumulation of industry price and sales data for several internet service devices at a certain point in time. How responsive are actual sales volumes in the industry to changes in price for different IT products? These data would begin to give a picture of how various technologies are perceived in terms of necessity versus luxury IT e-business products for companies. As a manager, if one were to see that the demand for certain kinds of products were more or less elastic, it might serve as a guide as to what kinds of information technologies were considered to be more or less critical in terms of benchmarking with the actions of the competition. This elasticity may vary by industry and risk, as banking may have a less elastic demand profile for bridge firewalls, for example, when compared to low volume, low price commodity retail industries on the internet.

4. Conclusion

Traditional MIS measures of IT payback have serious limitations in applicability for e-business situations due to construct validity questions about the impact of the technology being measured, a wide variance in results, and the presence of a gap between soft and hard types of measures. E-business, by the nature of its technology and the churning .com business environment, is a more complex evaluation problem in terms of IT payback than are traditional IT investments. Yet, as more and more firms construct e-business platforms using the tools of cross-functional, interorganizational electronic business networks and solutions, clearly an answer to the evaluation problem for e-business must be achieved. It is suggested here that a more comprehensive framework, one which includes a blended approach of qualitative and quantitative traditional MIS measures of implementation success, while also involving new measures derived from economic models, may contribute to improving the evaluation process of e-business investment projects.

References

Ackoff RL. Management misinformation systems. *Management Science* 1967;14(4):147–156.
Alpar P, Porembski M, Pickerodt S. Measuring efficiency of web site traffic generation. *International Journal of Electronic Commerce* 2001;6(1):53–74.
Bailey JE, Pearson SW. Development of a tool for measuring and analyzing computer user satisfaction. *Management Science* 1983;29(5):350–545.
Bariff M, Lusk EN. Cognitive personality tests for the design of MIS. *Management Science* 1977;23(8):820–829.
Barua A, Kriebel CH, Mukhopadhyay T. Information technologies and business value: An analytical emprical investigation. *Information Systems Research* 1995;6(1):3–23.
Benbasat I, Zmud RW. Empirical research in information systems: The practice of relevance. *MIS Quarterly* 1999;23(1):3–16.
Blair MM, Wallman SMH (eds.). *Unseen Wealth: Report of the Brookings Task Force on Intangibles*. Washington, DC: Brookings Institution Press, 2001.
Brynjolfsson E. The productivity paradox of information technology. *Communications of the ACM* 1993;36(12):67–77.
Brooks FP Jr. *The Mythical Man-Month*. 2nd edition. Reading, MA: Addison-Wesley, 1995.
Brynjolfsson E, Smith MD. Frictionless commerce? A comparison of internet and conventional retailers. *Management Science* 2000;46:563–585.
Carmines EG, Zeller RA. *Reliability and Validity Assessment*. Newbury Park: Sage Publications, 1979.
Cash JI, Konsynski BR. IS Redraws competitive boundaries. *Harvard Business Review*, March–April 1985. Reprinted in *Revolution in Real Time: Managing Information Technology in the 1990s*. Boston, MA: Harvard Business Review Book, 1991:95–111.
Cronbach LJ, Meehl PE. Construct validity in psychological tests. In: Jackson DN, Messick S, eds. *Problems in Human Assessment*. New York: McGraw-Hill Book Co., 1959:57–77.
Cusumano MA, Yoffie DB. *Competing on Internet Time: Lessons from Netscape and its Battle with Microsoft*. New York: The Free Press, 1998.
Cyert RM, March JG. *A Behavioral Theory of the Firm*. Englewood Cliffs, NJ: Prentice-Hall, 1963.
Davenport T. *Process Innovation: Reengineering Work Through Information Technology*. Boston: Harvard Business School Press, 1992.
Dearden J. MIS is a mirage. *Harvard Business Review* 1972;50(1):90–99.
DeLone WH, McLean ER. Information systems success: The quest for the dependent variable. *Information Systems Research* 1992;3(1):60–95.
Doll W, Torkzadeh G. The measurement of end user computing satisfaction. *MIS Quarterly* 1988;(June):259–274.
Dos Santos B. Justifying investments in new information technologies. *Journal of Management Information Systems* 1994;7(4);71–90.
Dos Santos B, Peffers K, Mauer D. The impact of information technology investment announcements on the market value of the firm. *Information Systems Research* 1993;4(1):1–23.
Eilon S. Measuring quality of information systems. *OMEGA* 1993;21(2):135–138.
Floyd SW, Woolridge W. Path analysis of the relationship between competitive strategy, information technology, and financial performance. *Journal of Management Information Systems* 1990;7(1):47–64.
Grove HD, Frank HS, Hanbery G. The effect of information system intangibles on the market value of the firm. *Journal of Information Systems* 1990;Fall:36–47.
Grover V, Teng TC, Fiedler KD. Information technology enabled business process redesign: An integrated planning framework. *OMEGA Int. J. of Management Science* 1993;21(4):433–447.
Harris SE, Katz JL. Organizational performance and information technology investment intensity in the insurance industry. *Organization Science* 1991;2(3):263–295.
Hammer M. Reengineering work: Don't automate, obliterate. *Harvard Business Review* July/August, 1990.
Hammer M, Champy J. *Reengineering the Corporation*. New York: Harper and Row, 1992.
Hitt L, Brynjolfsson E. The three faces of IT value: Theory and evidence. In: *Proceedings of the 15th International Conference of Information Systems*, Vancouver, Dec. 1994:263–277.
Hong Se-Joon. Information processing costs in online stock trading. *Electronic Markets* 2000;10(3):192–196.
Ives B, Olson M, Baroudi J. The measurement of user information satisfaction. *Communications of the ACM* 1983;26(10):785–793.
Keen Peter GW. *Competing In Time: Using Telecommunications for Competitive Advantage*. Ballinger Publishing Company, 1988.
Kemerer C. *Information Technology and Industrial Competitiveness: How "IT" Shapes Competition*. Boston: Kluwer Academic Publishers, 1998.
Klein S, O'Keefe B. Refining the measurement of e-commerce. *International Journal of Electronic Commerce* 2001;6(1):9.
Kuhn TS. *The Structure of Scientific Revolutions*, 2nd edn. Chicago: The University of Chicago Press, enlarged, 1970. Originally published in 1962.
Markus ML, Robey D. Information technology and organizational change-causal-structure in theory and research. *Management Science* 1988;34(5):583–598.
Lee C. Valuation of the internet infomediaries. Working Paper, June 2, 1999, National Taiwan University.
Lester RK. *The Productive Edge*. New York: W.W. Norton and Co., 1998.

Lucas HC Jr. *Information Technology and the Productivity Paradox*. New York: Oxford University Press, 1999.
Melone N. A theoretical assessment of the user-satisfaction construct in information systems research. *Management Science* 1990;36(1):76–91.
Perkins AB, Perkins MC. *The Internet Bubble: Inside the Overvalued World of High-Tech Stocks*. New York: HarperBusiness, 1999.
Porter M, Millar V. How information gives you competitive advantage. *Harvard Business Review* July/August, 1985.
Powell TC, DentMicallef A. Information technology as competitive advantage: The role of human, business and technology resources. *Strategic Management Journal* 1997;18(5):375–405.
Rangone A, Balocco R. A performance measurement system for planning and controlling a B2C e-commerce strategy. *Electronic Markets* 2000;10(2):130–143.
Reynolds PD. *A Primer in Theory Construction*. New York: MacMillan Publishing Co., 1971.
Sethi V, King WR. Construct measurement in information systems research. *Decision Sciences* 1991;22:455–472.
Shiller RJ. *Irrational Exuberance*. Princeton, NJ: Princeton University Press, 2000.
Steinbart PJ, Nath R. Problems and issues in the management of international data communications networks: The experience of American companies. *MIS Quarterly* 1992;(March):55–73.
Stewart TA. *Intellectual Capital: The New Wealth of Organizations*. New York: Doubleday, 1997.
Strassmann PA. *The Business Value of Computers: An Executive's Guide*. New Canaan, CT: The New Information Economics Press, 1990.
Tam KY. The impact of information technolgoy investments on firm performance and evaluation: Evidence from newly industrialized economies. *Information Systems Research* 1998;9(1):85–98.
Vehovar V, Manfreda KL, Batagelj Z. Sensitivity of e-commerce measurement to the survey instrument. *International Journal of Electronic Commerce* 2001;6(1):31–51.
Weill P. The relationship between investment in information technology and firm performance: A study of the valve manufacturing sector. *Information Systems Research* 1992;3(4):307–333.
Weill P, Olson MH. Managing investment in information technology: Mini case examples and implications. *MIS Quarterly* 1989;(March):3–17.

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